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Data Article

Data of heavy metals biosorption onto *Sargassum oligocystum* collected from the northern coast of Persian Gulf

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ABSTRACT

This data article presents a simple method for providing a biosorbent from *Sargassum oligocystum* harvested from the northern coast of Persian Gulf, Bushehr, Iran. The characterization data of *Sargassum oligocystum* biochar (SOB) were analyzed using various instrumental techniques (FTIR and XPS). The kinetics, isotherms, and thermodynamics data of Hg^{2+}, Cd^{2+}, and Cu^{2+} ions onto SOB were presented. The maximum biosorption capacity of SOB to uptake Hg^{2+}, Cd^{2+}, and Cu^{2+} ions from aqueous solution was obtained 60.25, 153.85, and 45.25 mg/g, respectively. The experimental data showed that biochar prepared from *Sargassum oligocystum* is an efficient and promising biosorbent for the treatment of heavy metals-bearing wastewaters.

Specifications Table

Subject area	*Environmental Engineering*
More specific subject area	*Biosorption*

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Type of data	Table, figure
How data was acquired	-The uptake of metals by the biosorbent (q_e) was determined based on the difference between the initial and final concentration of metals.- Fourier transform infrared (FTIR) spectroscopy (Shimadzu 4300), X-ray photoelectron spectrometer (KRATOS AXIS 165), and atomic absorption spectroscopy (AAnalyst 200 Perkin-Elmer).
Data format	Analyzed
Experimental factors	– *Sargassum oligocystum* biochar (SOB): The SOB was provided from brown alga of *S. oligocystum* at 350 °C. – Data of SOB were collected for Cd^{2+}, Cu^{2+}, and Hg^{2+} removal from solution. – - The data related to kinetics, isotherms, and thermodynamic was presented.
Experimental features	*S. oligocystum* biochar as Cd^{2+}, Cu^{2+}, and Hg^{2+} biosorbent.
Data source location	Bushehr University of Medical Sciences, Bushehr, Iran, GPS: 28.9667°N, 50.8333°E.
Data accessibility	Data are available with the article.

Value of the data

- A biochar provided from *Sargassum oligocystum* was applied for attenuating Cd^{2+}, Cu^{2+}, and Hg^{2+} from aqueous solution.
- Information of this data article including, isotherm, kinetic, and thermodynamic parameters will be informative for modeling and predicting the biosorption capacity and mechanism of heavy metal removal by algae.
- This data set will be beneficial for the scientific community wanting to scale up and design a biosorption column with *S. oligocystum* biochar as medium for the removal of heavy metal- bearing waters or wastewaters.

1. Data

The FTIR of the fresh and used SOB particles at wave numbers from 500 to 4000 cm^{-1} are shown in Fig. 1. The X-ray photoelectron spectroscopy (XPS) of fresh SOB and Cd^{2+}, Cu^{2+}, and Hg^{2+} loaded SOB is also depicted in Fig. 2. Data of this article including, kinetics, isotherms, and thermodynamic analysis was calculated using models provided in Table 1. The data of kinetics and isotherms for biosorption of heavy metals (cadmium, copper, and mercury ions) onto SOB were first depicted in Fig. 3 and 4. Through Fig. 3 and 4 and Table 1, the kinetics, isotherms, and thermodynamic parameters were calculated and summarized in Tables 2 and 3.

2. Experimental design, materials and methods

2.1. Materials

The mass of brown algae (*S. oligocystum*) was harvested from the Persian Gulf, Bushehr coast, Iran. The collected *S. oligocystum* masses were first washed with seawater for removing debris and sand and then shipped to the laboratory. In the laboratory the biomasses of *S. oligocystum* was washed extensively with running tap water for around 30 min followed by deionized water to remove

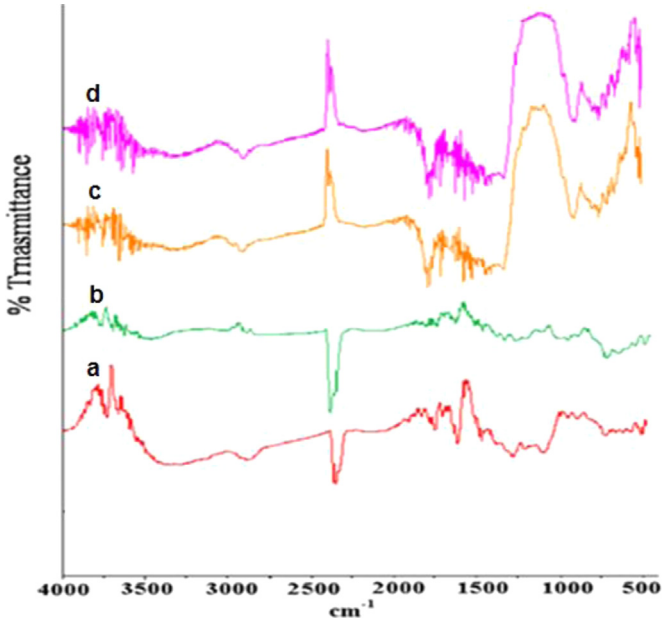

Fig. 1. FTIR spectra for (a) fresh SOB, (b) Cd- loaded, (c) Cu- loaded SOB, and (d) Hg- loaded SOB.

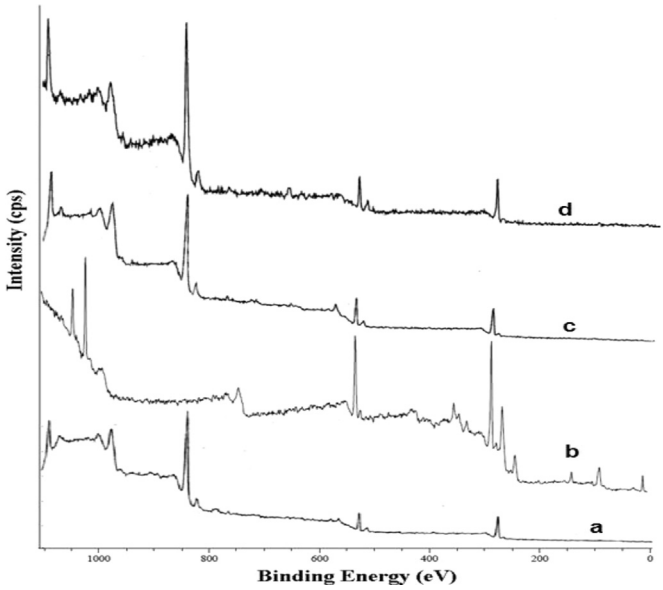

Fig. 2. XPS wide scan spectra for (a) fresh SOB, (b) Cd- loaded SOB, (c) Cu- loaded SOB, and (d) Hg loaded SOB.

impurities. After that, the biomass was dried at 350 °C for 2 h in a Muffle Furnace. The dried biomass (biochar) was ground to achieved a particle size of a 200-mesh (Φ= 0.074 mm). The obtained particles were used in the experiments as *S. oligocystum* biochar (SOB).

Table 1
Isotherm and kinetic models and thermodynamic equations used in this data article [1,2].

Model	Functional form	Plotting
Langmuir	$\frac{q_e}{q_m}=\frac{K_L C_e}{1+K_L C_e}$	$\frac{1}{q_e}$ vs $\frac{1}{C_e}$
Freundlich	$q_e=K_f C_e^{1/n}$	log $m_1=f_2/f_1$
Temkin	$\frac{q_e}{q_m}=\frac{RT}{b_T}\ln(k_T C_e)$	q_e vs lnC_e
Halsey	$q_e=k_H/CH_e^{1/n_H}$	log $q_e$vslogC_e
Pseudo 1st order	$\frac{dq}{dt}=k_1(q_e-q_t)$	log (q_e-q_t)vs$t$
Pseudo 2nd order	$q_t=\frac{q_e^2 k_2 t}{1+q_e k_2 t}$	$\frac{t}{q_t}$ vs t
Intraparticle diffusion	$q_t=k_{ip}t^{0.5}$	$q_t$vs $t^{0.5}$
Bangham	$\ln\left(1-\frac{q_t}{q_e}\right)=-k_B t$	$\ln\left(1-\frac{q_t}{q_e}\right)$vs t
Thermodynamics	$\Delta G^\circ=-RT\ln K_{Th}$; $\ln K_{Th}=(\Delta S^\circ/R)-(\Delta H^\circ/RT)$; $\Delta G^\circ=\Delta H^\circ-T\Delta S^\circ$	ln K_{Th} vs $1/T$

q_m = maximum adsorption capacity, k_L= Langmuir constant, k_f and n = Freundlich constants; and k_T and b_T = Temkin constants, k_1 = rate constant of pseudo-first order model, k_2 = rate constant of pseudo-second order model, k_{ip} = intraparticle diffusion constant, k_B= Bangham constant, q_t= adsorbed amount at any time, q_e = adsorbed amount at equilibrium, R = universal gas constant, T = absolute temperature in Kelvin (298 K), ΔG°= Gibbs free energy change (kJ/mol), ΔH°= enthalpy change (kJ/mol), ΔS°= entropy change (kJ/mol K), and K_{Th}= thermodynamic equilibrium constant (mL/g).

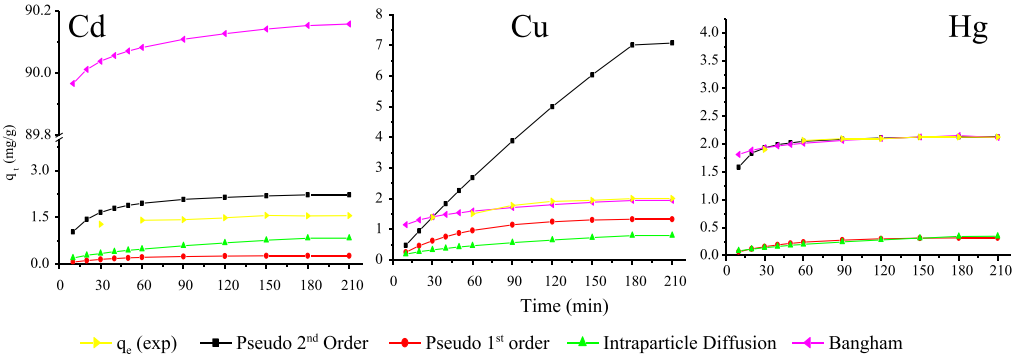

Fig. 3. Biosorption kinetics for Cd, Cu, and Hg using SOB (120 rpm, 24 °C, 10 g/L biosorbent, optimum pH).

2.2. Experimental design

Biosorption batch tests with the prepared SOB were conducted in 100 mL flask and stirred at 120 rpm in a shaker–incubator instrument (Parsazma Co., Iran). Each test contained of preparing 50 mL of adsorbate (Cd, Cu, and Hg) with a given initial concentration. The initial pH of the solution was regulated as required by addition of 0.1 M HCl and NaOH solutions. After the sample reached equilibrium, the sample was passed through a 0.42 μm- filter, and the final concentration of the contaminant was determined. The amounts of contaminant adsorbed per gram of SOB, q_e (mg/g), were obtained as follows [3,4]:

$$q_e=\frac{C_0-C_e}{M} \tag{1}$$

where C_0 and C_e (mg/L) are contaminant concentrations at initial and equilibrium, respectively. M (g/L) denote the dry mass of SOB in the solution.

Isotherms analyses were performed with various initial concentrations of Cd^{2+}, Cu^{2+}, and Hg^{2+} (see x- axis of Fig. 4), contact time of 8 h, solution temperature 24 °C, and mixing intensity of 120 rpm. Kinetic tests were done using a known initial concentration at 24 °C for a determined contact time (t=0–210 min).

Table 2
Kinetics parameters for Cd, Cu and Hg adsorbed onto SOB.

Parameter	Cd	Cu	Hg
$q_{e,\ exp}$ (mg/g)	2.385	2.004	2.126
Pseudo 1st order			
$q_{e,cal}$ (mg/g)	0.610	1.362	0.318
k_1 (min^{-1})	−0.041	0.020	0.022
R^2	0.901	0.984	0.916
SD	0.069	0.089	0.203
Pseudo 2nd order			
$q_{e,cal}$ (mg/g)	1.424	2.101	2.173
k_2 (g/mg.min)	0.702	0.029	0.124
R^2	1.000	0.946	0.999
SD	0.032	0.028	0.019
Intraparticle diffusion			
K_{ip} ($mg/g.min^{0.5}$)	0.025	0.120	0.025
R^2	0.879	0.999	0.879
SD	0.045	0.0002	0.045
Bangham			
K_{BM}	0.126	−142.032	−124.362
α	5.99E−04	0.182	0.059
R^2	0.955	0.937	0.926
SD	4.20E−05	0.022	0.008

Table 3
Isotherms and thermodynamic parameters for Cd, Cu, and Hg adsorbed onto SOB.

Parameter	Cd	Cu	Hg
$q_{e,exp}$ (mg/g)	217.155	42.111	229.993
Freundlich			
K_f (L/g)	1.128	1.414	1.787
n	0.983	2.267	1.026
R^2	0.994	0.875	0.977
SD	0.044	0.024	0.019
Langmuir			
K_L (L/mmol)	0.005	0.011	0.066
q_m (mg/g)	153.85	45.250	60.250
R^2	0.998	0.984	0.749
SD	0.025	2.330	0.099
Temkin			
K_T (L/mmol)	0.115	0.122	0.187
R^2	0.939	0.955	0.993
SD	0.069	5.746	0.095
Halsey			
k_H (L/g)	0.359	0.165	0.253
n_H	−0.687	−2.267	−1.026
R^2	0.997	0.874	0.976
SD	0.029	0.523	0.028

Thermodynamic parameters

at 297K	ΔG° (KJ/mol)	ΔS° (KJ/mol)	ΔH° (KJ/mol)	R^2/ *SD*
Cd	−2.451	0.0019	−1.852	0.986/ 0.007
Cu	−0.632	0.829	−0.381	0.914/0.006
Hg	−16.157	0.022	−9.395	0.992/0.026

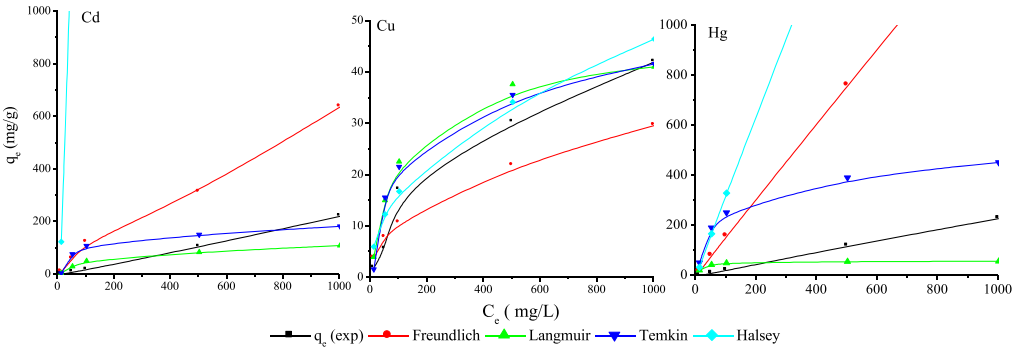

Fig. 4. Biosorption isotherm for Cd, Cu and Hg using SOB (120 rpm, 24 °C, 10 g/L biosorbent, 2 h, optimum pH).

The thermodynamics of biosorption process of Cd^{2+}, Cu^{2+}, and Hg^{2+} onto SOB was assessed using a 100-mL flask, containing 50 mL of pre-determined concentration of the adsorbate, 10 g/L SOB, mixing intensity of 120 rpm. This test was performed at designated temperature (24 °C). The thermodynamics of contaminants biosorption onto SOB was analyzed using an estimated change in biosorption free energy ($\Delta G°$), biosorption enthalpy ($\Delta H°$), and biosorption entropy ($\Delta S°$) as defined in the Table 1.

All biosorption tests were performed at least in duplicate to ensure the reproducibility of data, and the average values are stated herein. Blank tests containing no SOB were also undertaken.

2.3. Analytical methods

FTIR spectra for fresh and used SOB samples were recorded by the KBr pellets method operated on FTIR spectrophotometer (Shimadzu 4300, Japan). Data processing was performed to transform absorbance into transmittance percentage showing wavelength peaks. The residual concentration of Cd^{2+}, Cu^{2+}, and Hg^{2+} ions in the treated solutions was analyzed using an atomic absorption spectroscopy (AAnalyst 200 Perkin-Elmer). The initial and final pH of the solution was measured using a pH meter (METLER TOLEDO FE20). The surface of the SOB samples before and after heavy metals adsorption was analyzed by using an X-ray photoelectron spectrometer (XPS, KRATOS AXIS 165). The XPS was operated at a base pressure of 8×10^{-8} Pa and pass energy of 23.5 eV. The calibration of the spectra was done by graphitic carbon as the energy referenced to C1s at 284.6 eV.

The value of correlation coefficients (R^2) and the standard deviation (SD) of data was used to assess the goodness of the kinetic and isotherm models. SD can be expressed as:

$$SD = \sqrt{\frac{1}{n}\sum_{i=1}^{n}\left(X_i - \overline{X}\right)^2} \tag{2}$$

where X_1, X_2, …, X_n are the obtained values of the measurements, $\overline{X}$ is the average value of the measurements, and n is the size of the sample.

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Appendix A. Transparency Document

Transparency document data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.dib.2016.05.035.

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